# THE WEATHER AND CIRCULATION OF SEPTEMBER 1953 [1]

## Another Dry Month in the United States

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### THE DROUGHT

During the summer of 1953 drought conditions developed in many portions of the United States. In June Texas and neighboring States were most severely affected [1]. During July North Carolina and Virginia had the greatest deficiency of precipitation [2]. In August Tennessee and Indiana had the least percentage of normal rainfall of any State in the Nation [3]. For the summer as a whole, however, Missouri had the greatest deficit of moisture by a wide margin. Figure 1a show sthat statewide precipitation in Missouri during June, July, and August of 1953 averaged only 44 percent of normal. This map illustrates the widespread nature of this summer's drought since it shows subnormal rainfall amounts in about three-fourths of the States.

During September the nationwide dry spell intensified. The weighted precipitation average for the United States, an index computed from statewide precipitation amounts weighted according to the area of each State, was only 1.54 inches, nearly an inch less than the September normal and the third lowest on record (beginning 1893). This was also the fourth consecutive month with the Nation's weighted precipitation average below the 60-year normal. Practically all portions of the country except the Southeast and the Northwest Coast had below normal rainfall during the month, with less than one-fourth of the normal amount in most of the area west of the Mississippi River (Chart III–B). Figure 1b shows subnormal precipitation in all but six States during September. The driest State of the Nation, on both an absolute and relative basis, was Arizona whose average rainfall of 0.02 inch was only 1 percent of the normal amount and the lowest on record for September. In Missouri the summer drought condition became aggravated still further during September, when statewide rainfall averaged only 29 percent of normal. Springfield, Mo., with only 2.52 inches of rain from June 1 to October 3, reported the driest four consecutive months in its weather history and an accumulated precipitation deficiency of 22.71 inches over a 22-month period. As a result of the prolonged and widespread nature of the dry spell, the Mississippi River reached its lowest level in history on October 5 at Memphis Tenn.

### RELATED CIRCULATION FEATURES

The 700-mb. circulation responsible for September's dry weather is illustrated in figure 2. This chart shows a well-defined sinusoidal wave pattern over the Pacific and North America consisting of abnormally strong ridges in the west central Pacific and western North America and deeper than normal troughs in the eastern Pacific and eastern North America. The degree of unusualness of

[1] See charts I–XV following p. 317 for analyzed climatological data for the month.

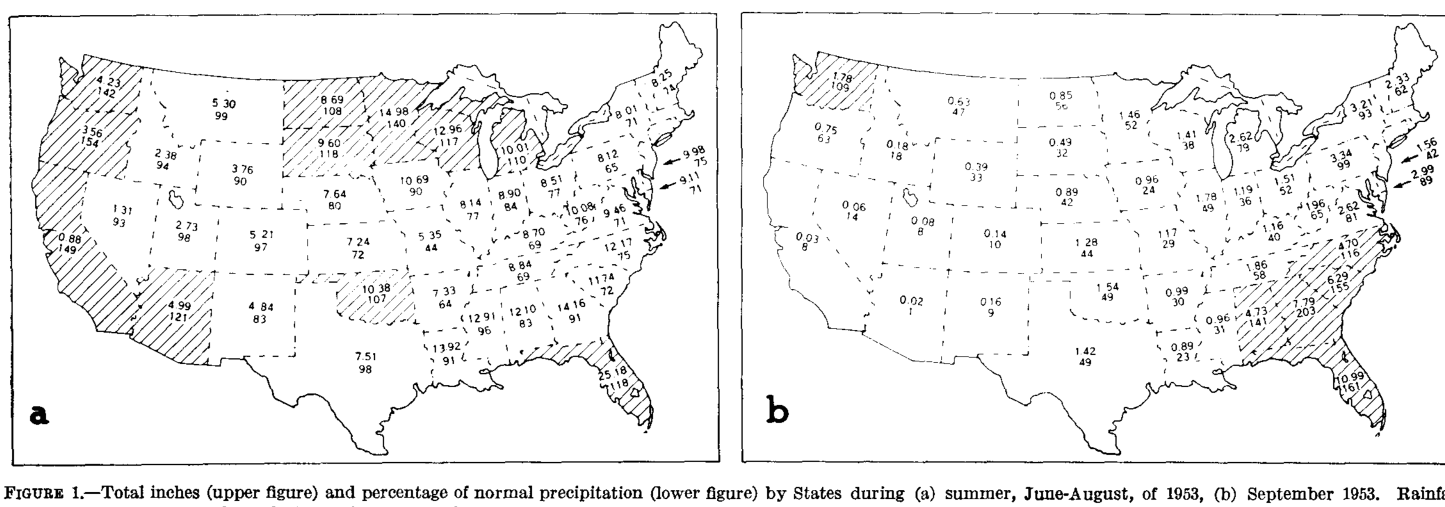



FIGURE 1.—Total inches (upper figure) and percentage of normal precipitation (lower figure) by States during (a) summer, June-August, of 1953, (b) September 1953. Rainfall was greater than normal (shaded) in only 11 States during the summer season and 6 States during September. For the entire 4-month period Missouri had the greatest moisture deficiency.

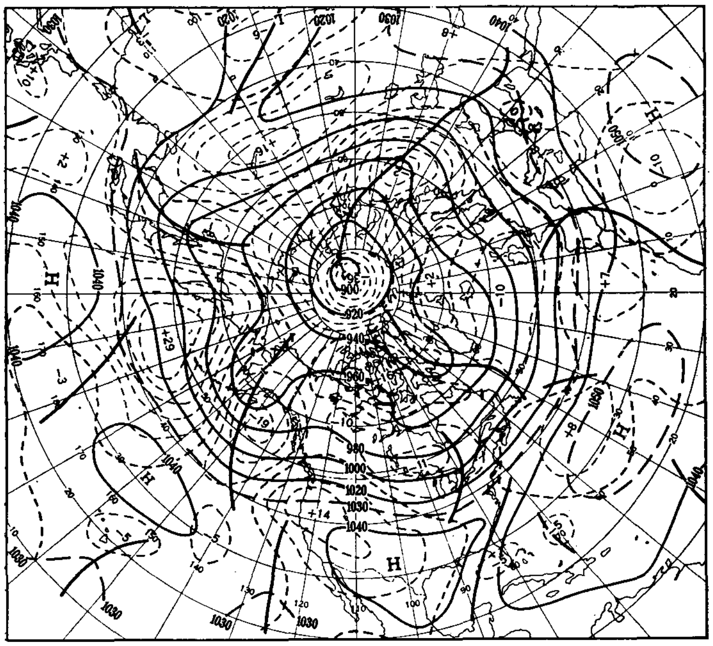


FIGURE 2.—Mean 700-mb. height contours and departures from normal (both in tens of feet) for September 1–30, 1953. Northerly components of anomalous flow (parallel to dashed lines) in most of the United States produced prevailingly dry weather (fig. 1b) by preventing entry of moisture from the Gulf of Mexico.

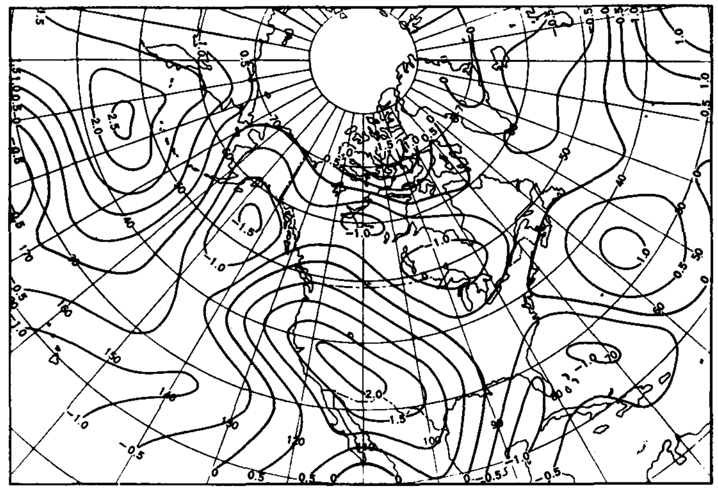


FIGURE 3.—Departures from normal of monthly mean 700-mb. height for September 1–30, 1953, in standard deviation units. Positive height anomalies in the ridge in the western United States (fig. 2) corresponded to standardized departures of as much as 2 units and therefore to probabilities of chance occurrence of approximately 3 in 100.

these features may be derived from figure 3 which gives the geographical distribution of the standardized departure from normal of monthly mean 700-mb. height. It was computed at standard intersections by dividing the observed height anomalies shown in figure 2 by their respective standard deviations (computed from September mean 700-mb. charts for the period 1933 to 1951). Although the departures in figures 2 and 3 are the same in sign, their magnitudes differ because of the large variation of standard deviation from place to place. For example, negative height anomalies of $-110$ ft. in the Upper Lakes region and $-50$ ft. in Florida in figure 2 both correspond to standardized departures of $-1$ unit in figure 3. The largest height departure on the map, $+290$ ft. in mid-Pacific, was 2.5 standard deviations above the normal value. If we assume random sampling from a normally distributed population without serial correlation from one year to the next, then the probability of obtaining a positive standardized departure from normal of this magnitude or larger is about 1 in 100. This month's positive height anomalies in the southwestern United States were also extremely unusual. Although less than half of the positive anomaly in mid-Pacific in absolute magnitude, their standardized departure ($+2.0$ units) was almost as great. Making the assumptions previously stated, we may conclude that mean 700-mb. height departures from normal as large or larger than those observed this month in the Southwest would be expected to occur by chance in that area only about 3 times in 100 in September.[2]

[2] All probabilities were estimated by entering a table of "Student's t" distribution with 18 degrees of freedom.

Between the unusually strong ridge in the western United States and the deeper than normal trough complex near the east coast abnormally strong northwesterly winds covered most of the country. Likewise at sea level the anomalous flow components were mostly from a northerly direction (Chart XI inset). This circulation prevented appreciable northward transport of moist tropical air from the Gulf of Mexico but instead carried dry polar air across the country in repeated surges. It was also probably accompanied by considerable horizontal divergence and thus was unfavorable to cyclonic development. It has long been known that northwesterly flow at 700 mb. between a ridge in the Western United States and a trough in the East favors dry weather, particularly during the cooler part of the year (for recent studies substantiating this concept see [4] and [5]). The effects of this type of circulation were well illustrated in October 1952, the driest month on record in the United States and one with a circulation quite similar to this month's but even more extreme [6].

During the summer season, on the other hand, when wind speeds and wave lengths are smaller than in winter, drought is generally found below a strong warm High, the great North American high level anticyclone first described by Reed [7]. This continental High is usually accompanied by a fast stream of westerlies in southern Canada, an abnormally strong ridge in the east-central Pacific, and a deeper than normal trough along the west coast. As a result of this circulation widespread subsidence occurs over the United States, with heat and drought the inevitable result if the phenomenon is sufficiently prolonged. Good examples of this drought-producing circulation were observed early last summer [8] and again this year in both June and August [1 and 3]. The same circulation features are illustrated in figure 4, which gives the seasonal mean 700-mb. map for the three summer months of June, July, and August 1953. Note particularly the presence of stronger than normal ridges in the Mississippi Valley and eastern Pacific separated by a deep trough along the west coast. Figure 4 also shows that during the summer, as well as in September, moist tropical air was prevented from entering the United States by anomalous flow from the northeast all along the coast of the Gulf of Mexico.

Since September is a transition month, its circulation during 1953 retained some of the drought-producing characteristics of the summer type, in addition to its dry wintertime aspects previously described. For example, a well-developed High was centered over Texas at the 700-mb. level (fig. 2). To the north a belt of strong westerly winds stretched along the border between the United States and Canada, at both 200 mb. (fig. 5) and 700 mb. (fig. 6a). Monthly mean wind speeds were greater than the normal 700-mb. wind speed throughout this zone by as much as 10 m. p. h. in the Northern Plains and Pacific Northwest (fig. 6b). This "high index" condition prevented deep cold air masses from penetrating the country and therefore minimized the opportunity for intense cyclonic developments and accompanying precipitation. South of the westerly jet stream strong anticyclonic shear contributed to the stronger than normal anticyclonic vorticity which covered most of the United States at the 700-mb. level (fig. 7). At the same time cyclonic vorticity was more intense than normal in most of Canada. Concomitantly, migratory daily cyclones were abundant in Canada but less frequent in the United States (Chart X). Anticyclones, on the other hand, traversed the United States at frequent intervals during the month (Chart IX).

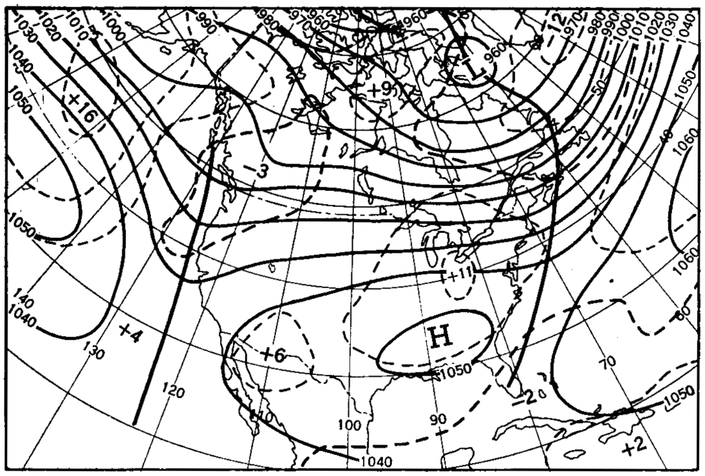


FIGURE 4.—Mean 700-mb. height contours at 100-ft. intervals (solid lines) and departure from normal at 50-ft. intervals (dashed lines) for June 1–August 30, 1953. The summer drought (fig. 1a) was most severe under and east of the stronger than normal ridge in the Mississippi Valley.

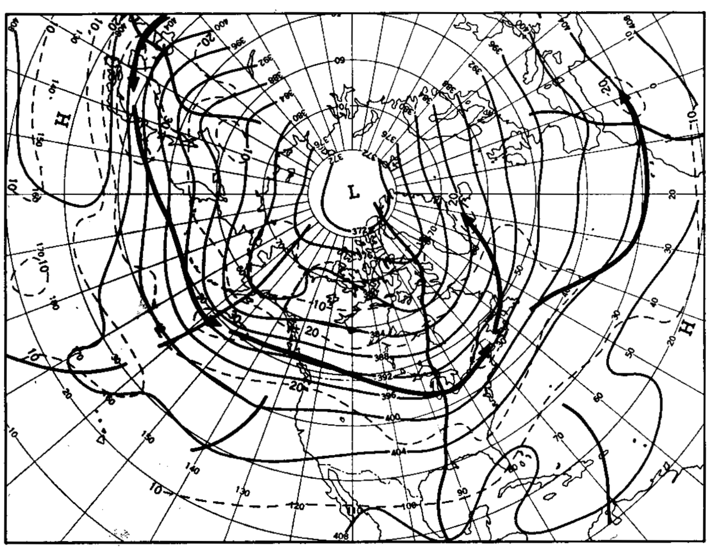


FIGURE 5.—Mean 200-mb. contours (in hundreds of feet) and isotachs (in meters per second) for September 1–30, 1953. Solid arrows indicate the average position of the jet stream, which corresponded closely with the position of the axis of maximum wind speed at 700 mb. (fig. 6a).

The only part of the United States where an above normal influx of moist air is indicated by the monthly mean circulation is the Southeast where winds were somewhat more southerly and easterly than normal at both 700 mb. (fig. 2) and sea level (Chart XI inset). In this region heavy rains fell, as much as three times the normal amount in parts of Florida, Georgia, and Alabama (Chart III). Statewide precipitation in Georgia averaged more than twice the normal amount (fig. 1b). Much of this rainfall occurred during the passage of several tropical disturbances (Chart X). The most intense of these was Hurricane "Florence" which originated in the Caribbean on September 23 and entered the mainland of the United States over northwestern Florida on the 26th attended by winds of 90 m. p. h. and rainfall of as much as 12 inches. Additional aspects of the monthly mean charts indicative of heavy rain in the Southeast are below normal pressures and a well-defined easterly wave at sea level (Chart XI), below normal heights in a sharp trough at 700 mb. (fig. 2), and more cyclonic vorticity than normal at 700 mb. (fig. 7).

## TEMPERATURES

The pattern of surface temperature anomalies during September in the United States (Chart I–B) was typical of that found during predominantly dry weather in the cooler months. Above normal temperatures prevailed throughout the western half of the country underneath the ridge aloft, while mostly below normal temperatures occurred beneath the trough conditions over the East. Such a distribution of temperature and height is unfavorable for cyclonic development and hence for precipitation. This simple pattern of temperature anomaly (warm in the West, cool in the East) was complicated by the presence of a stronger than normal belt of westerlies along the northern border of the United States (fig. 6). As a result of this "high index" condition, cold polar anticyclones from Canada were unable to penetrate the United States to any appreciable extent (Chart IX). At the same time maritime tropical air was effectively shut off by prevailingly northerly flow along the Gulf

Coast. Most of the country was therefore dominated by air masses of Pacific origin throughout the month. This air was relatively mild since sea surface temperatures are normally high during September. As a result temperatures during the month averaged above normal in all the northern border States. Only in the Southeast, where normal temperatures are still quite high during September, were the polar Pacific air masses cool enough to result in below normal temperatures for the month as a whole. Cool weather in this area was also associated with below normal sunshine (Chart VII) and solar radiation (Chart VIII) combined with excessive cloudiness (Chart VI) and precipitation (Chart III).

Many high temperature records were broken during the month. The intense heat wave in the Northeast during the first few days of September was discussed in last month's article [3]. Another record-breaking heat wave occurred during the last week of the month. Temperatures soared as high as 105° F. on September 28 in Concordia, Kans., and Fort Worth, Tex., while 102° was reported by St. Louis, Mo., the next day. Temperatures in Dallas, Tex., and Springfield, Mo., were a full 9° higher than ever before recorded so late in the season as September 28. It is interesting to note that this was the fifth consecutive month characterized by a severe heat wave in a large portion of the eastern half of the United States during the last week of the month. Additional weather highlights of September included destructive typhoons in Japan and Indochina on the 26th, gales in the eastern Atlantic on the 22d, and a hurricane in Bermuda on the 18th.

## REFERENCES

1. J. S. Winston, "The Weather and Circulation of June 1953—The Second Successive June with Record-Breaking Drought and Heat," *Monthly Weather Review*, vol. 81, No. 6, June 1953, pp. 163–168.

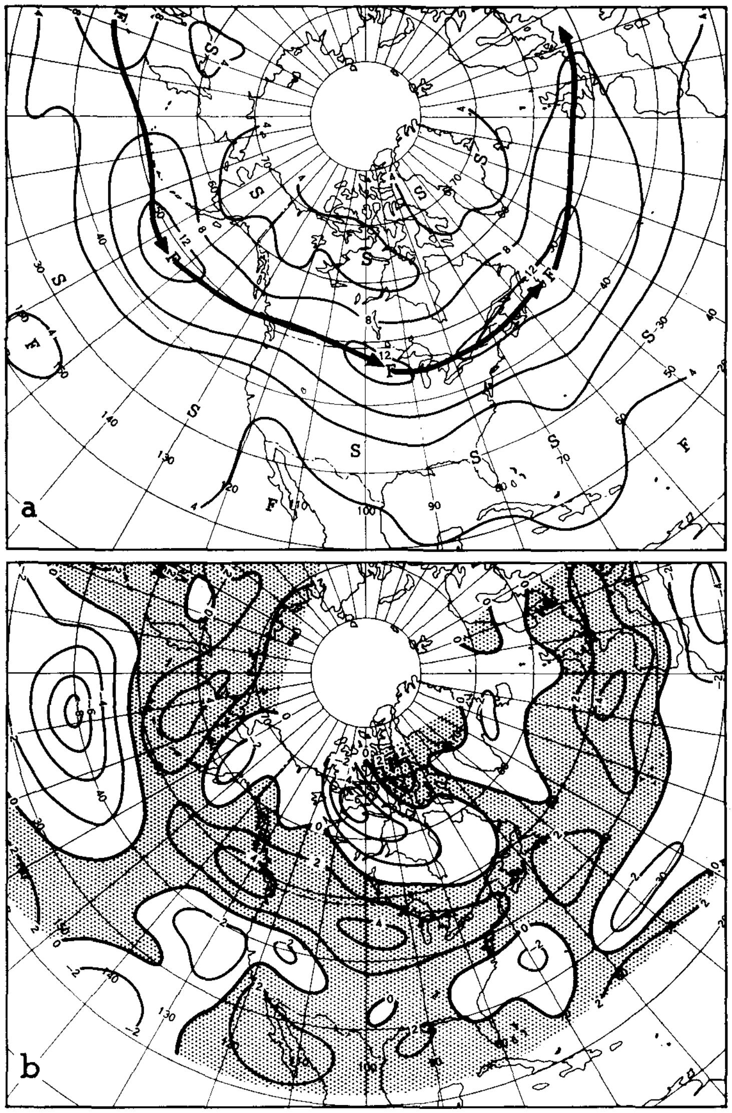



FIGURE 6.—Mean 700-mb. isotachs (a) and departure from normal wind speed (b) (both in meters per second) for September 1–30, 1953. Note stronger than normal wind speeds (shaded) along the northern border of the United States, associated with prevailingly warm, dry weather in the country.

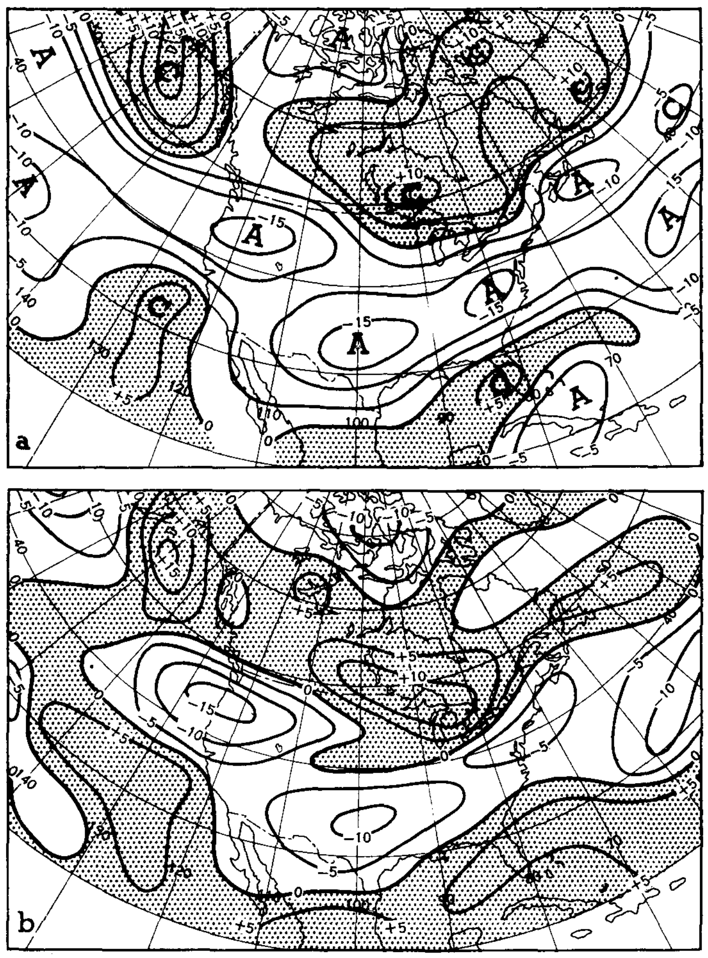
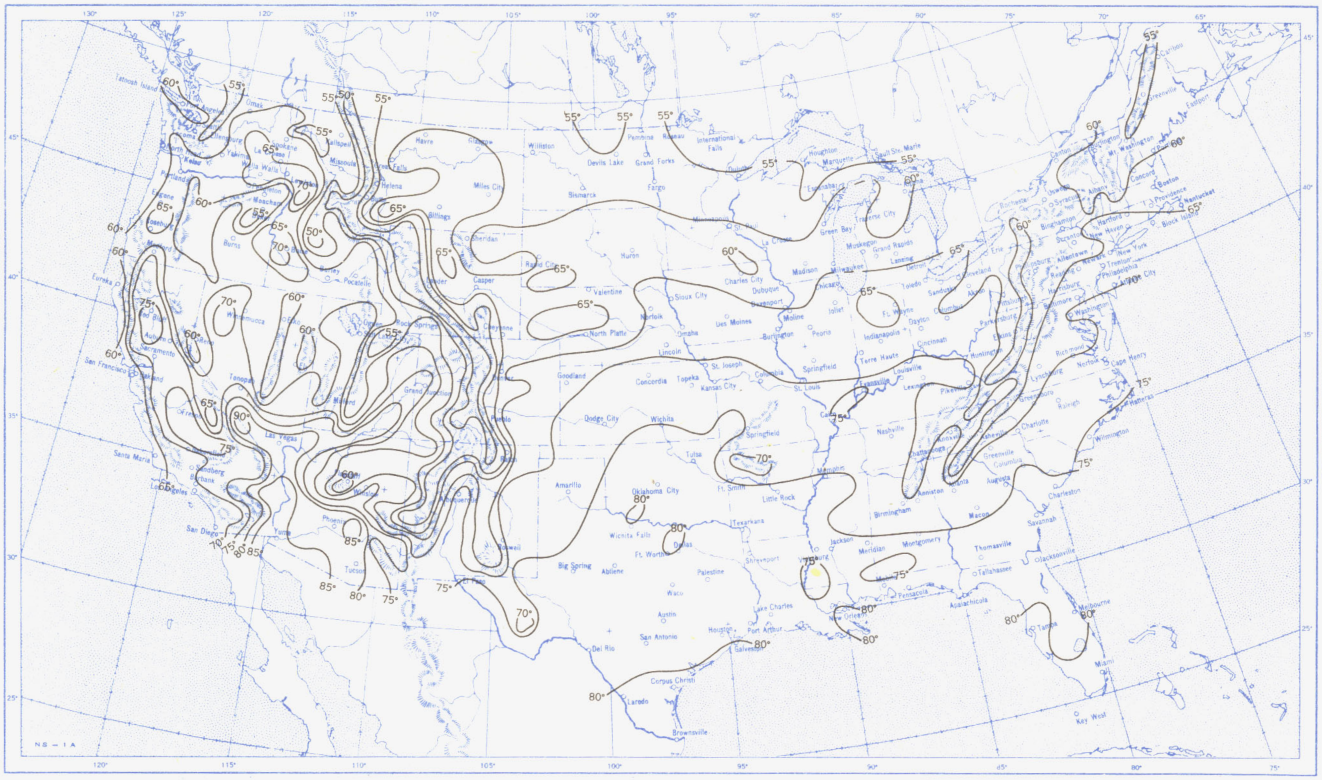


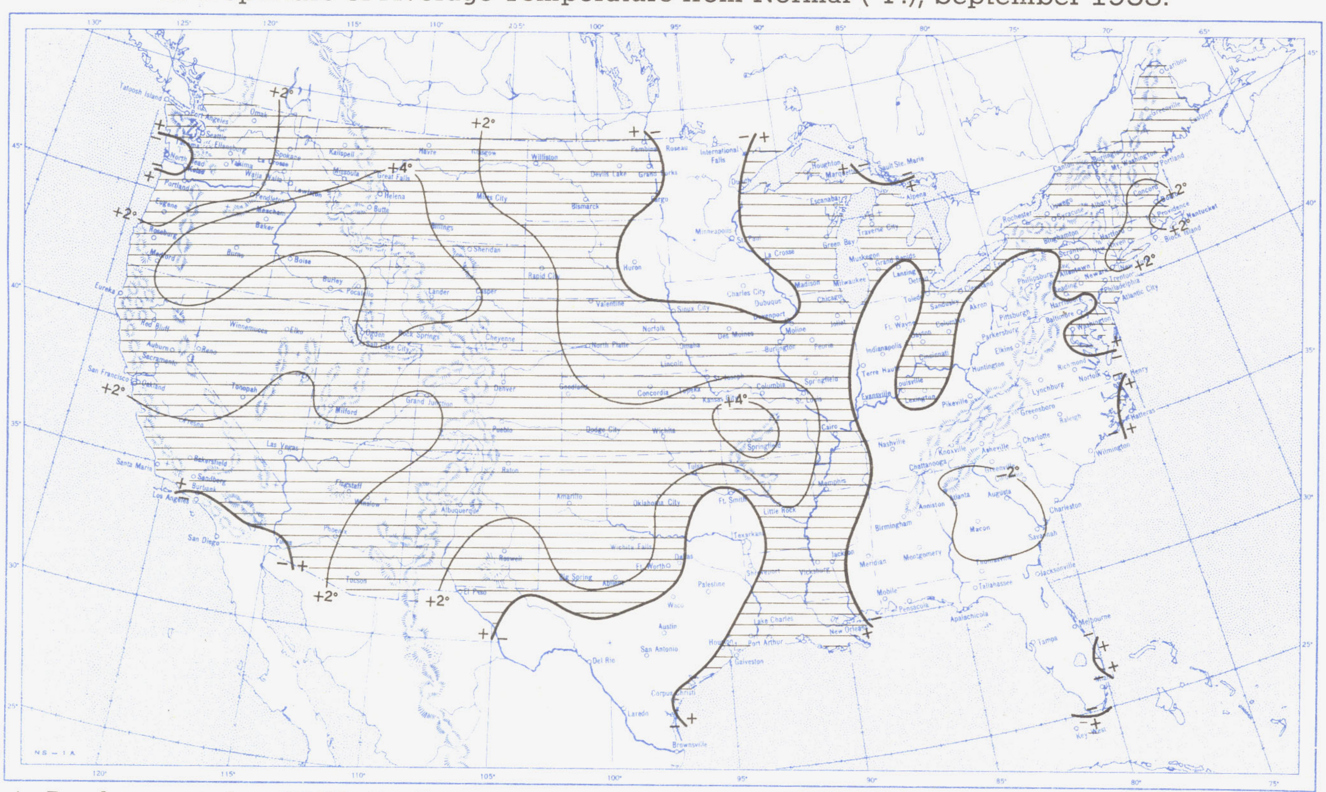

FIGURE 7.—Mean relative geostrophic vorticity at 700 mb. (a) and departure from normal vorticity (b) (both in units of $10^{-6}$ sec$^{-1}$) for September 1–30, 1953. Greater than normal cyclonic vorticity (shaded) prevailed in the Southeast where precipitation was heavy (fig. 1b), but greater than normal anticyclonic vorticity (negative values was accompanied by dry weather in most of the remainder of the United States.

2. H. F. Hawkins, Jr., "The Weather and Circulation of July 1953," *Monthly Weather Review*, vol. 81, No. 7, July 1953, pp. 204–209.
3. W. H. Klein, "The Weather and Circulation of August 1953—Featuring an Analysis of Dynamic Anticyclogenesis Accompanying Record Heat and Drought," *Monthly Weather Review*, vol. 81, No. 8, Aug. 1953, pp. 246–254.
4. C. K. Stidd, The Use of Correlation Fields in Relating Precipitation to Circulation, U. S. Weather Bureau, 1953. (To be published.)
5. W. H. Klein, "An Objective Method of Forecasting Five-Day Precipitation for the Tennessee Valley," *Research Paper No. 29*, U. S. Weather Bureau, Washington, D. C., 1949, 60 pp.
6. J. S. Winston, "The Weather and Circulation of October 1952—The Driest Month on Record in the United States," *Monthly Weather Review*, vol. 80, No. 10, Oct. 1952, pp. 290–294.
7. T. R. Reed, "Further Observations on the North American High-Level Anticyclone," *Monthly Weather Review*, vol. 65, No. 10, Oct. 1937, pp. 364–366.
8. W. H. Klein, "The Early Summer Drought of 1952," *Weatherwise*, vol. 5, No. 5, Oct. 1952, pp. 111–113.

## Chart I. A. Average Temperature (°F.) at Surface, September 1953.



## B. Departure of Average Temperature from Normal (°F.), September 1953.

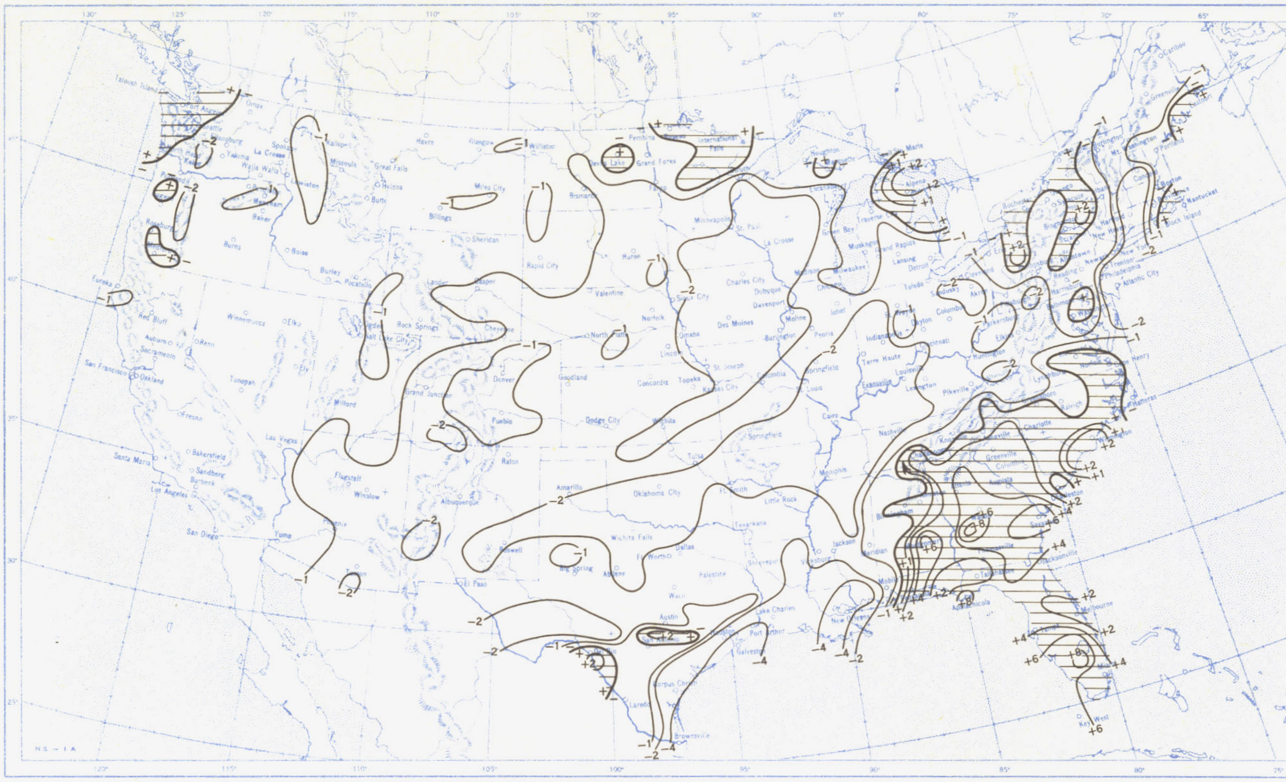


A. Based on reports from 800 Weather Bureau and cooperative stations. The monthly average is half the sum of the monthly average maximum and monthly average minimum, which are the average of the daily maxima and daily minima, respectively.
B. Normal average monthly temperatures are computed for Weather Bureau stations having at least 10 years of record.

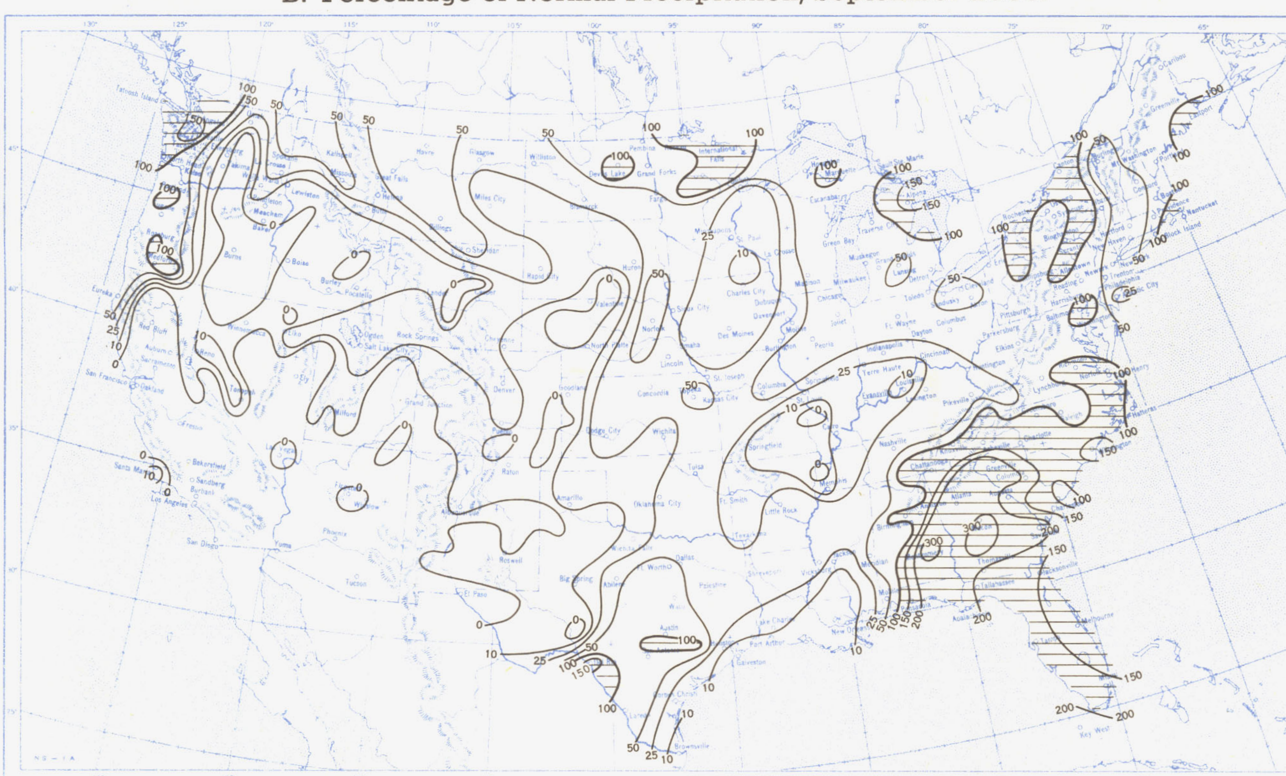
Chart II. Total Precipitation (Inches), September 1953.


Based on daily precipitation records at 800 Weather Bureau and cooperative stations.

## Chart III. A. Departure of Precipitation from Normal (Inches), September 1953.

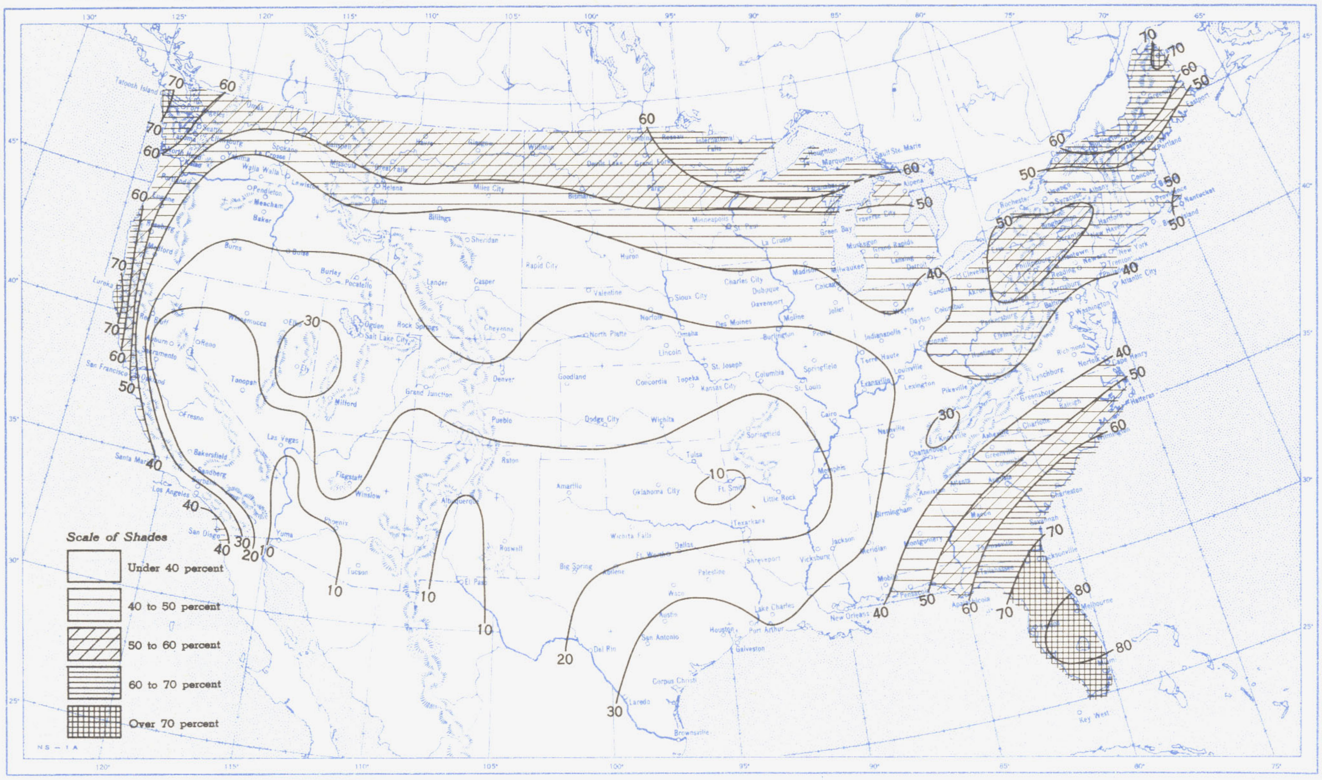


## B. Percentage of Normal Precipitation, September 1953.

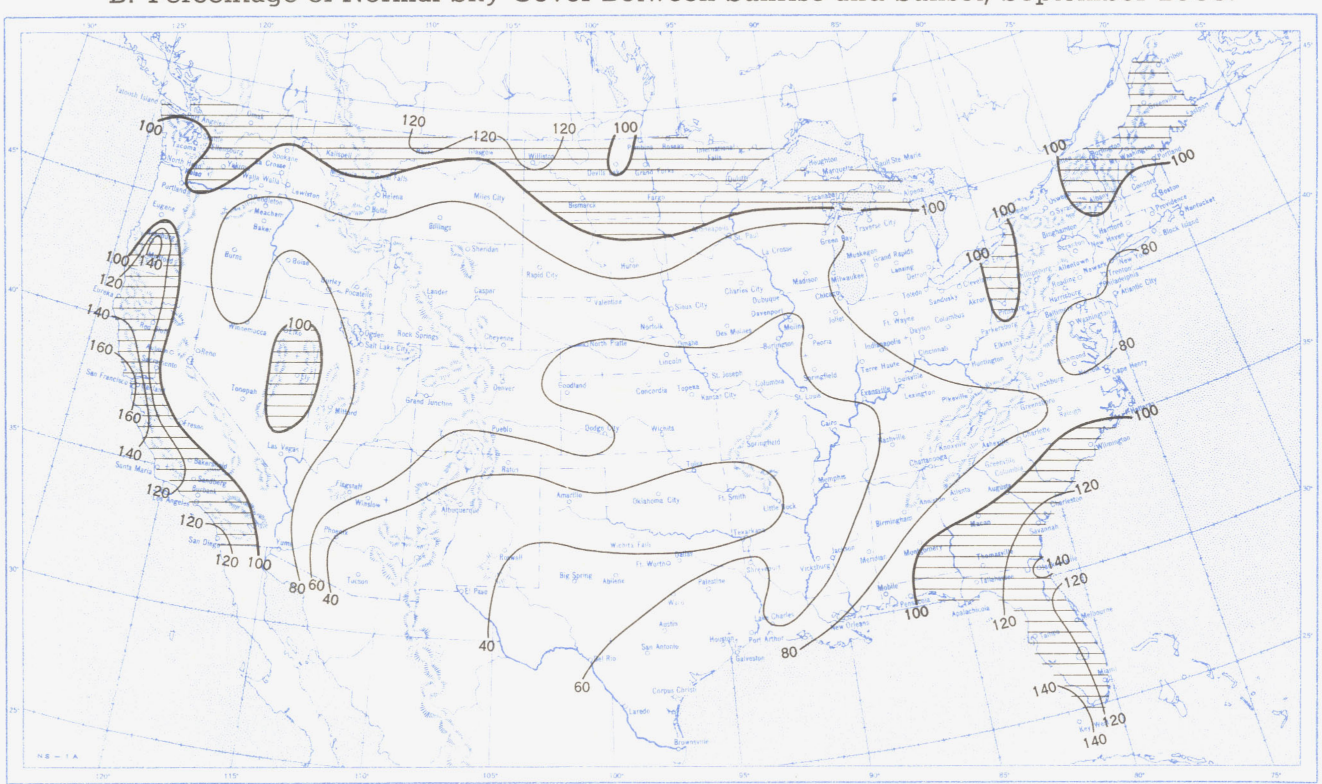


Normal monthly precipitation amounts are computed for stations having at least 10 years of record.

## Chart VI. A. Percentage of Sky Cover Between Sunrise and Sunset, September 1953.

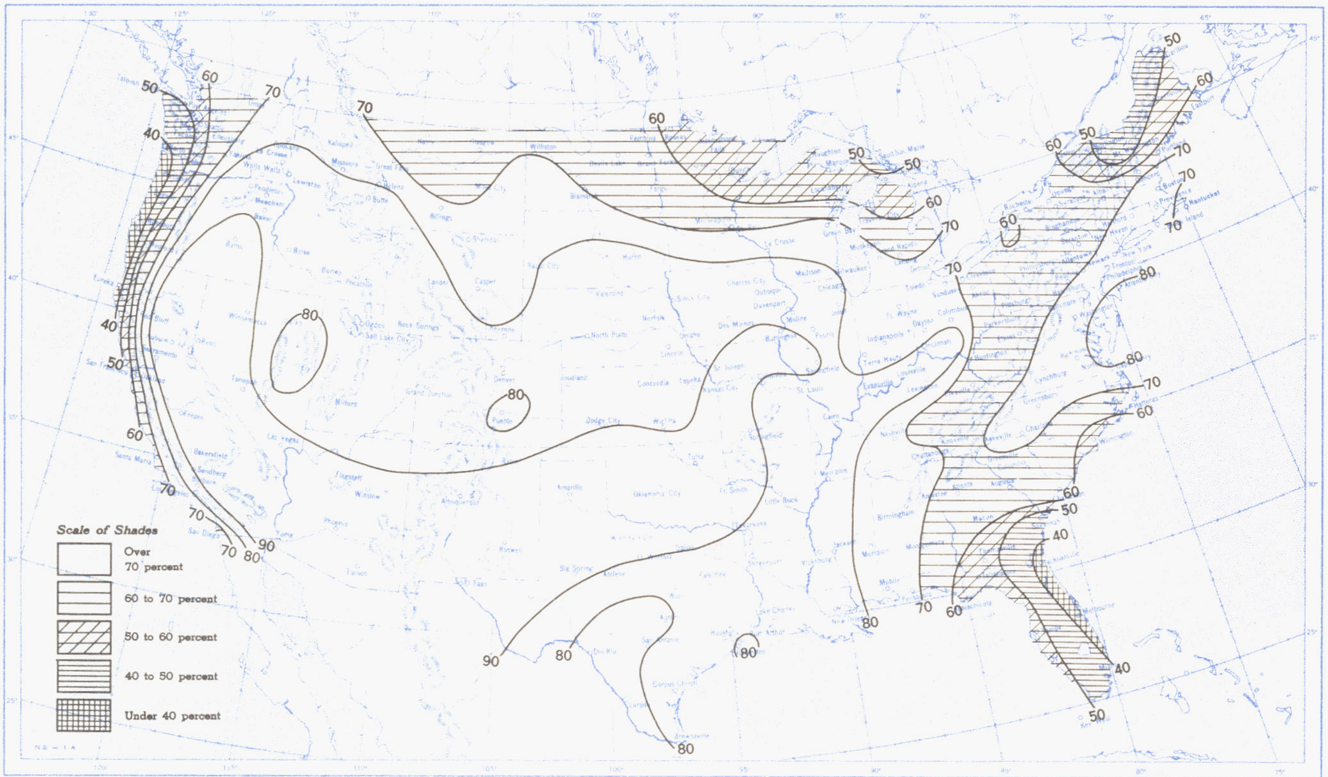



## B. Percentage of Normal Sky Cover Between Sunrise and Sunset, September 1953.

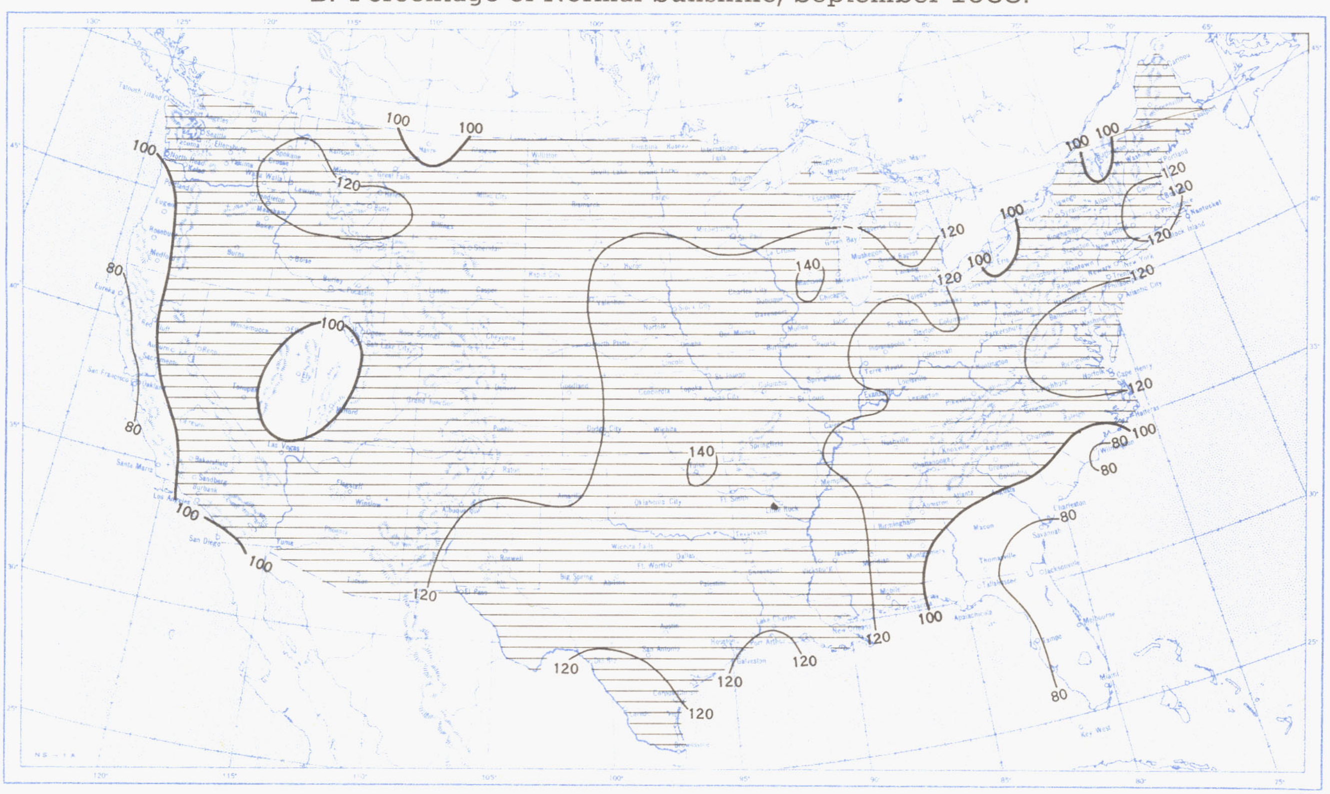


A. In addition to cloudiness, sky cover includes obscuration of the sky by fog, smoke, snow, etc. Chart based on visual observations made hourly at Weather Bureau stations and averaged over the month. B. Computations of normal amount of sky cover are made for stations having at least 10 years of record.

## Chart VII. A. Percentage of Possible Sunshine, September 1953.




## B. Percentage of Normal Sunshine, September 1953.



A. Computed from total number of hours of observed sunshine in relation to total number of possible hours of sunshine during month. B. Normals are computed for stations having at least 10 years of record.

Chart VIII. Average Daily Values of Solar Radiation, Direct + Diffuse, September 1953. Inset: Percentage of Normal Average Daily Solar Radiation, September 1953.

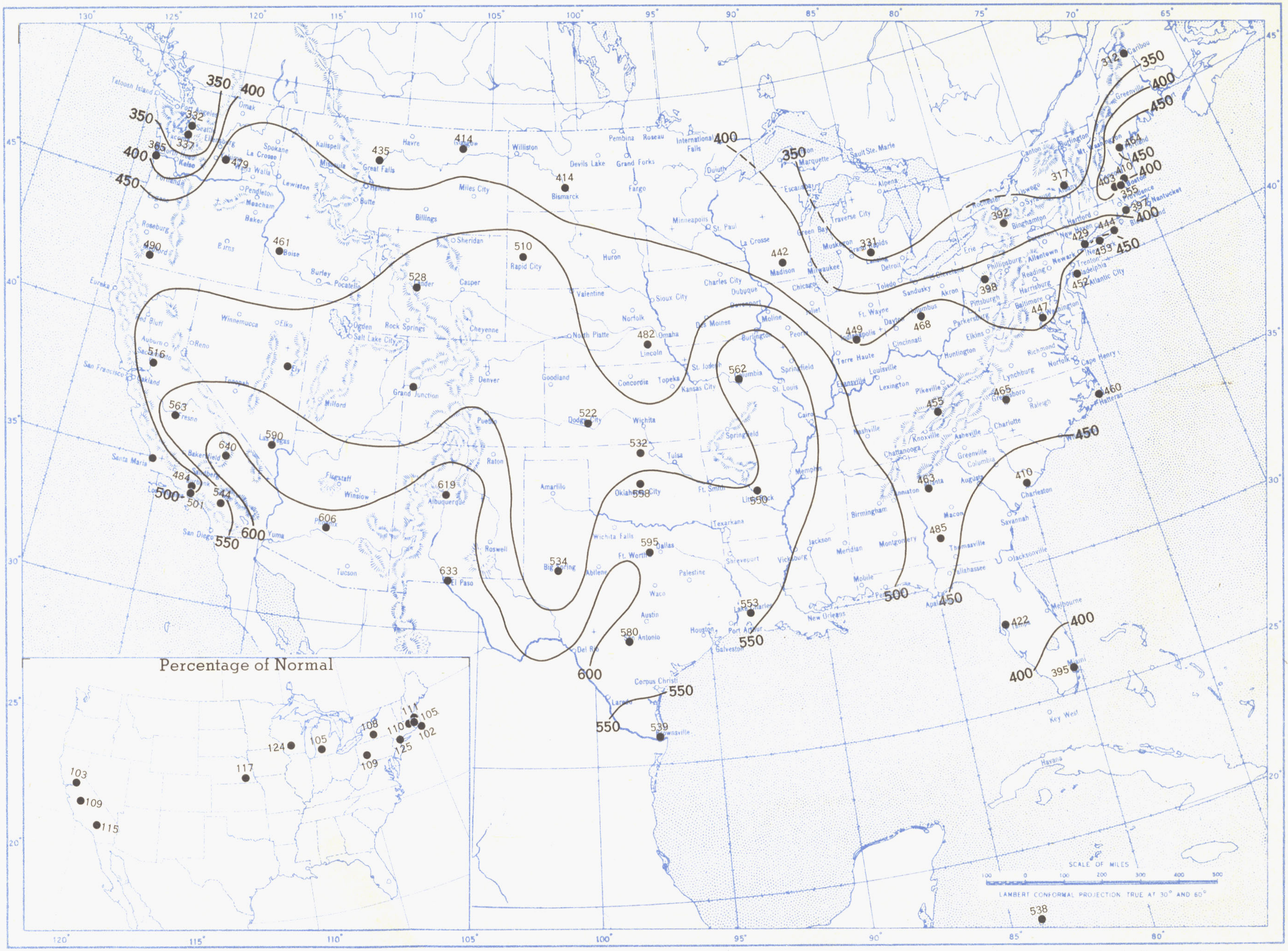
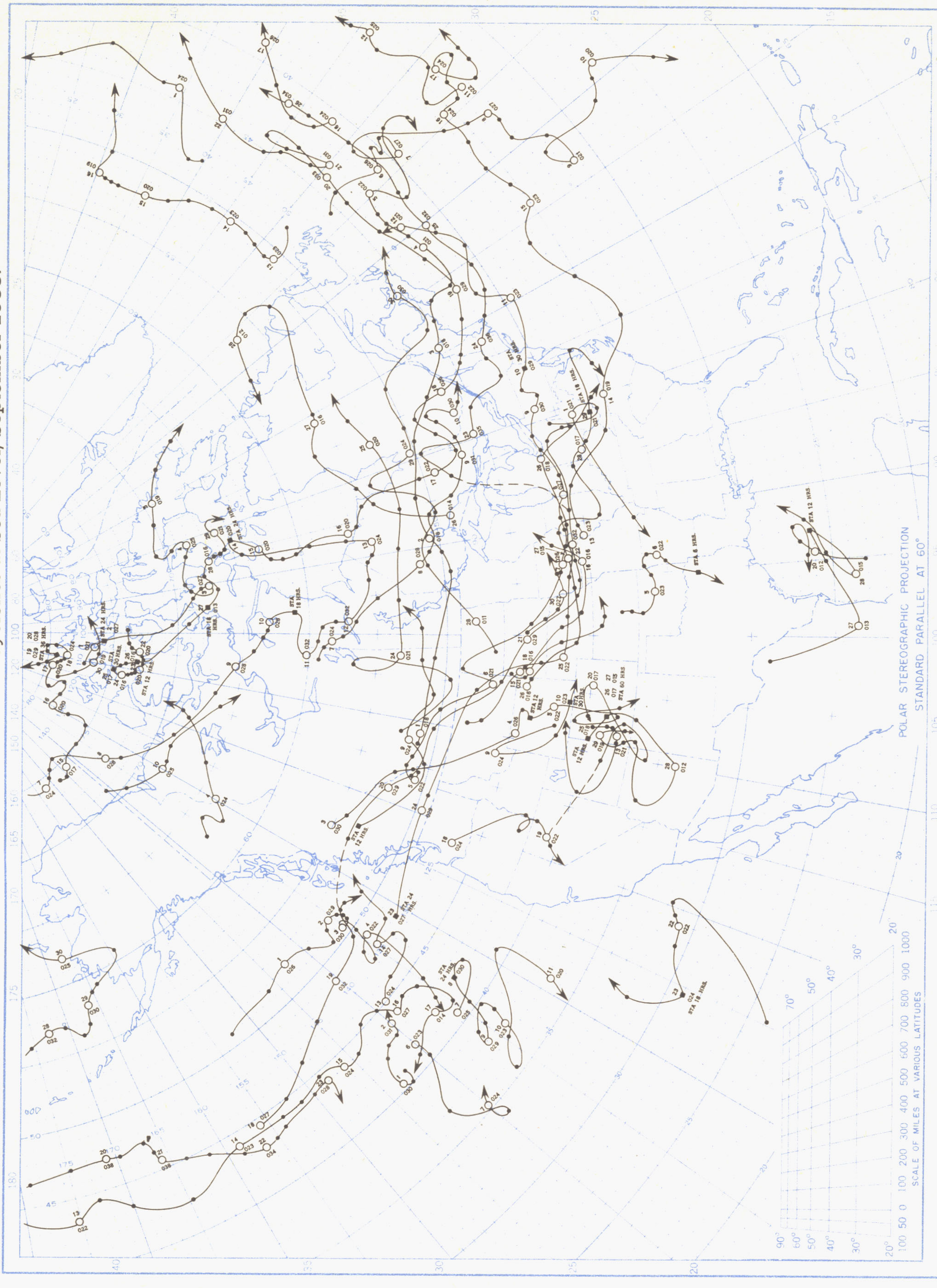


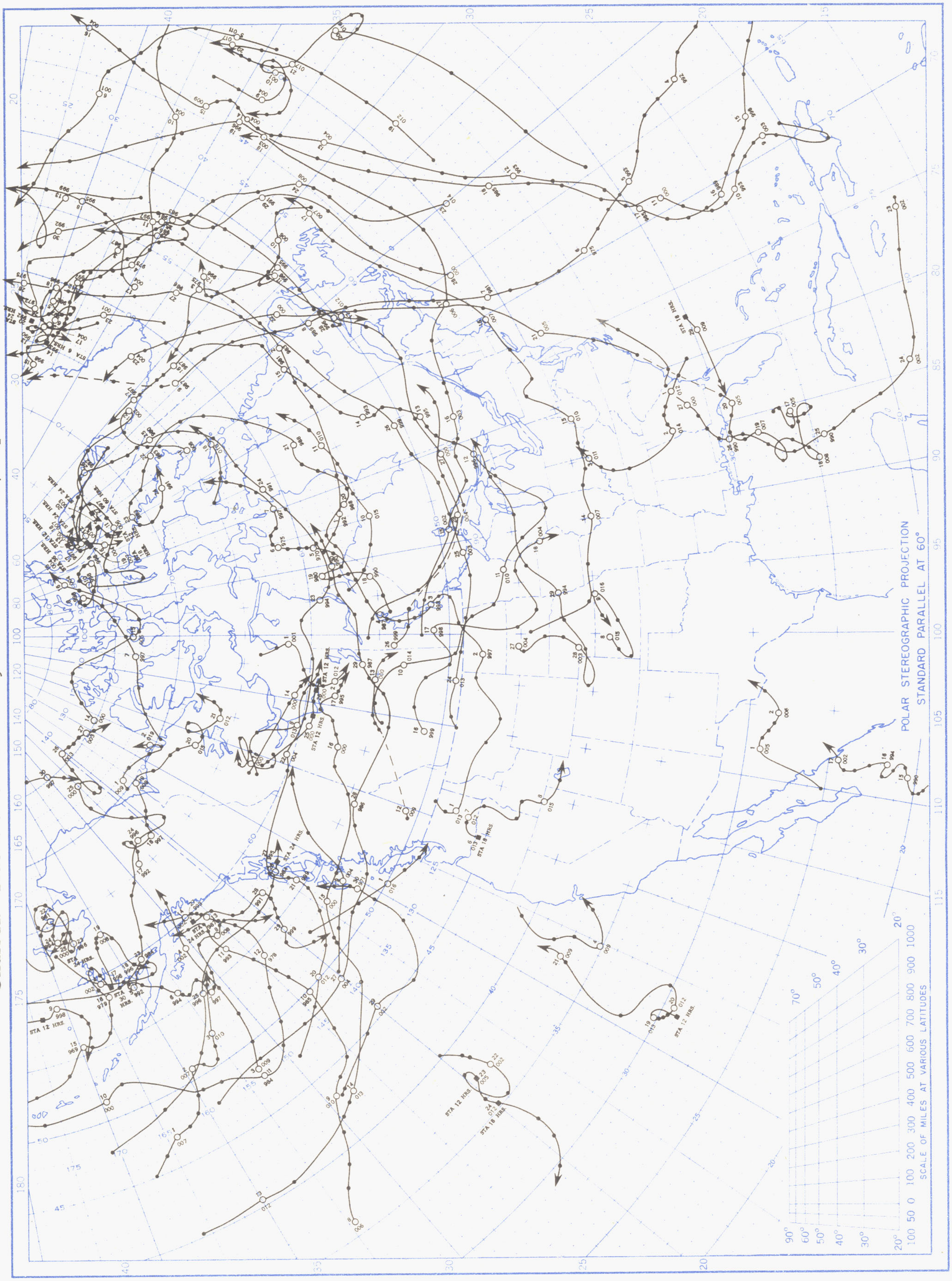

Chart shows mean daily solar radiation, direct + diffuse, received on a horizontal surface in langleys (1 langley = 1 gm. cal. cm. $^{-2}$). Basic data for isolines are shown on chart. Further estimates are obtained from supplementary data for which limits of accuracy are wider than for those data shown. Normals are computed for stations having at least 9 years of record.

# Chart IX. Tracks of Centers of Anticyclones at Sea Level, September 1953.



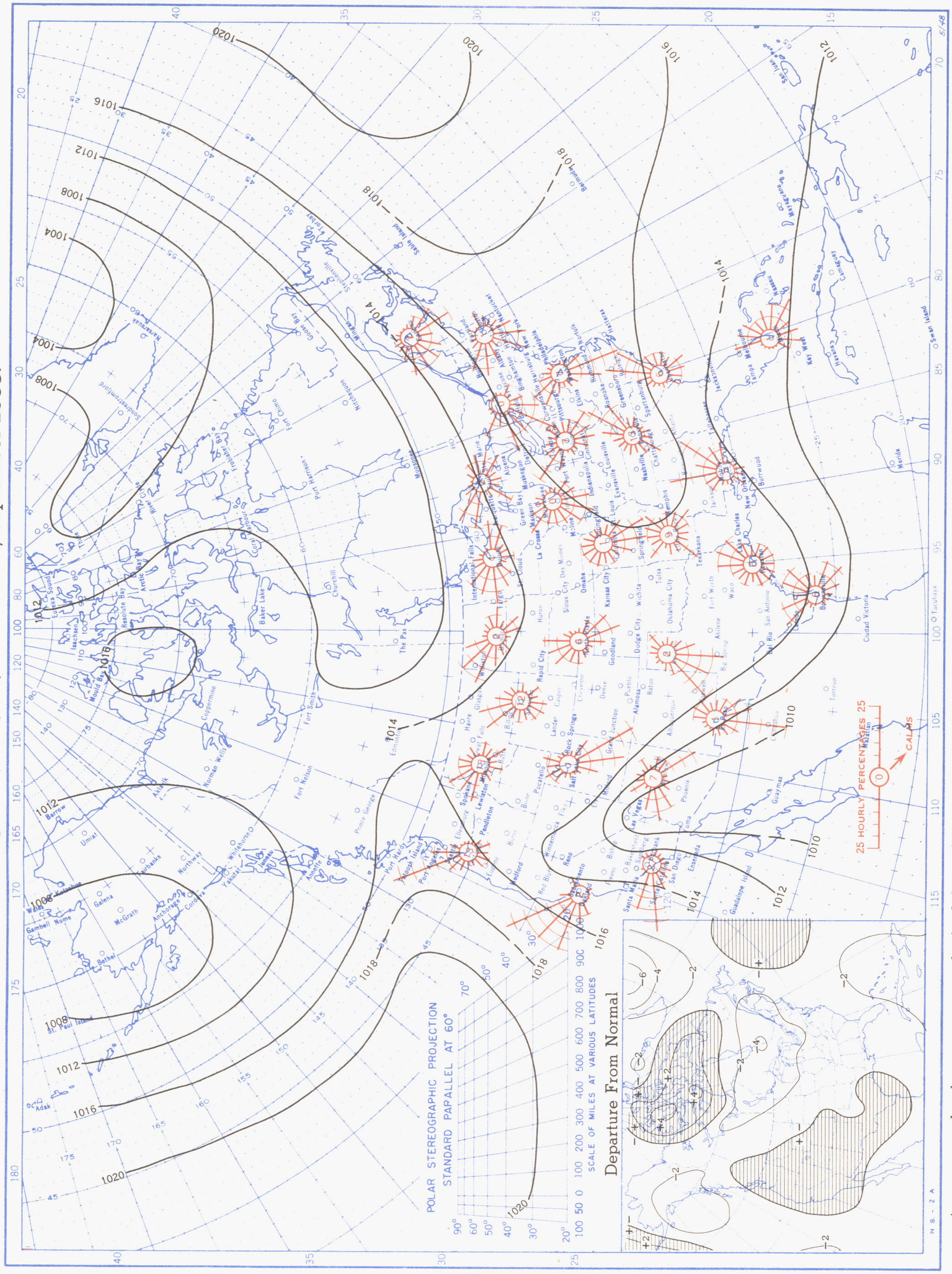

Circle indicates position of center at 7:30 a. m. E. S. T. Figure above circle indicates date, figure below, pressure to nearest millibar. Dots indicate intervening 6-hourly positions. Squares indicate position of stationary center for period shown. Dashed line in track indicates reformation at new position. Only those centers which could be identified for 24 hours or more are included.

# Chart X. Tracks of Centers of Cyclones at Sea Level, September 1953.



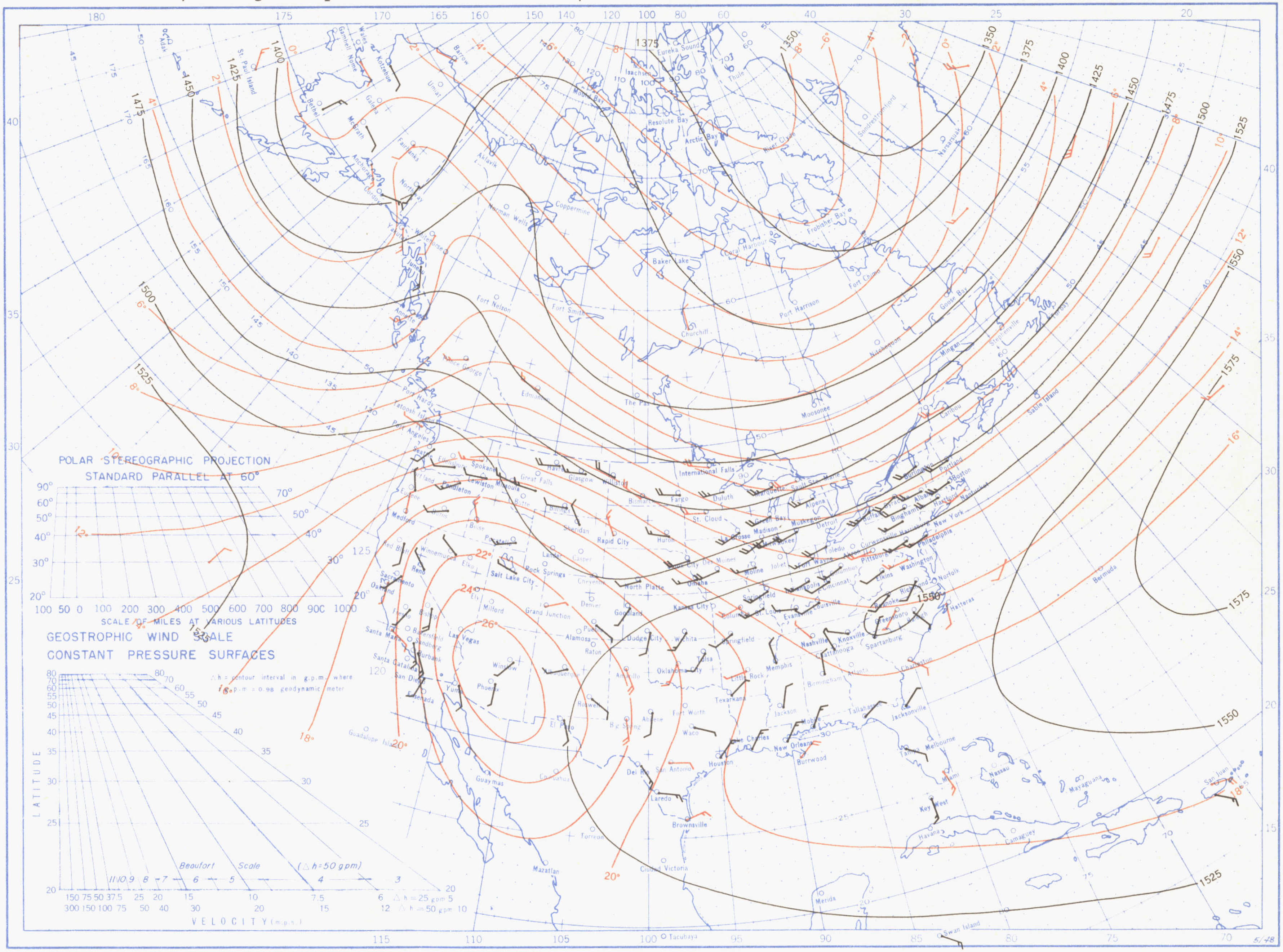

Circle indicates position of center at 7:30 a. m. E. S. T. See Chart IX for explanation of symbols.

Chart XI. Average Sea Level Pressure (mb.) and Surface Windroses, September 1953. Inset: Departure of Average Pressure (mb.) from Normal, September 1953.



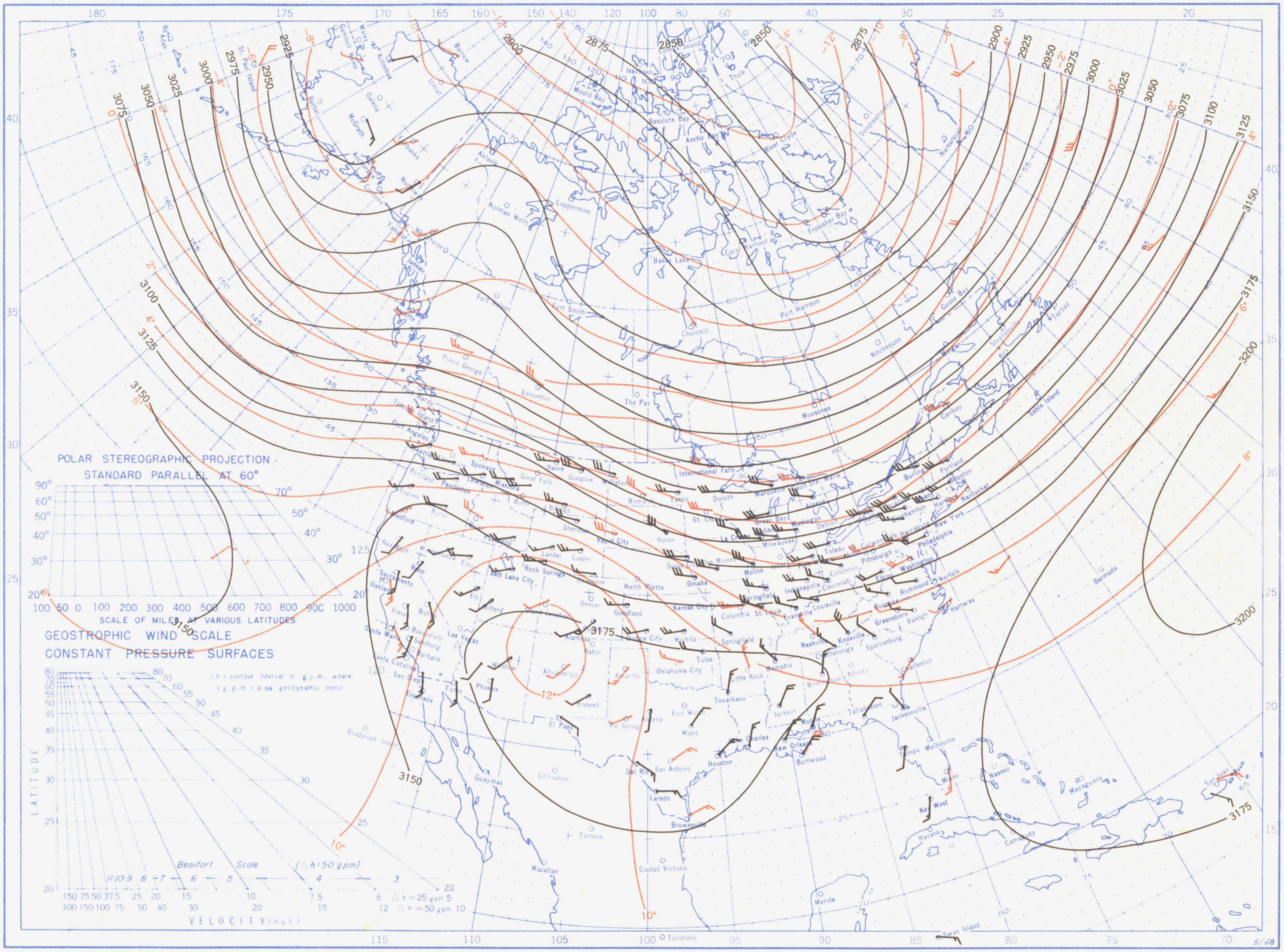

Average sea level pressures are obtained from the averages of the 7:30 a.m. and 7:30 p.m. E. S. T. readings. Windroses show percentage of time wind blew from 16 compass points or was calm during the month. Pressure normals are computed for stations having at least 10 years of record and for 10° intersections in a diamond grid based on readings from the Historical Weather Maps (1899-1939) for the 20 years of most complete data coverage prior to 1940.

Chart XII. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 850-mb. Pressure Surface, Average Temperature in °C. at 850 mb., and Resultant Winds at 1500 Meters (m.s.l.), September 1953.



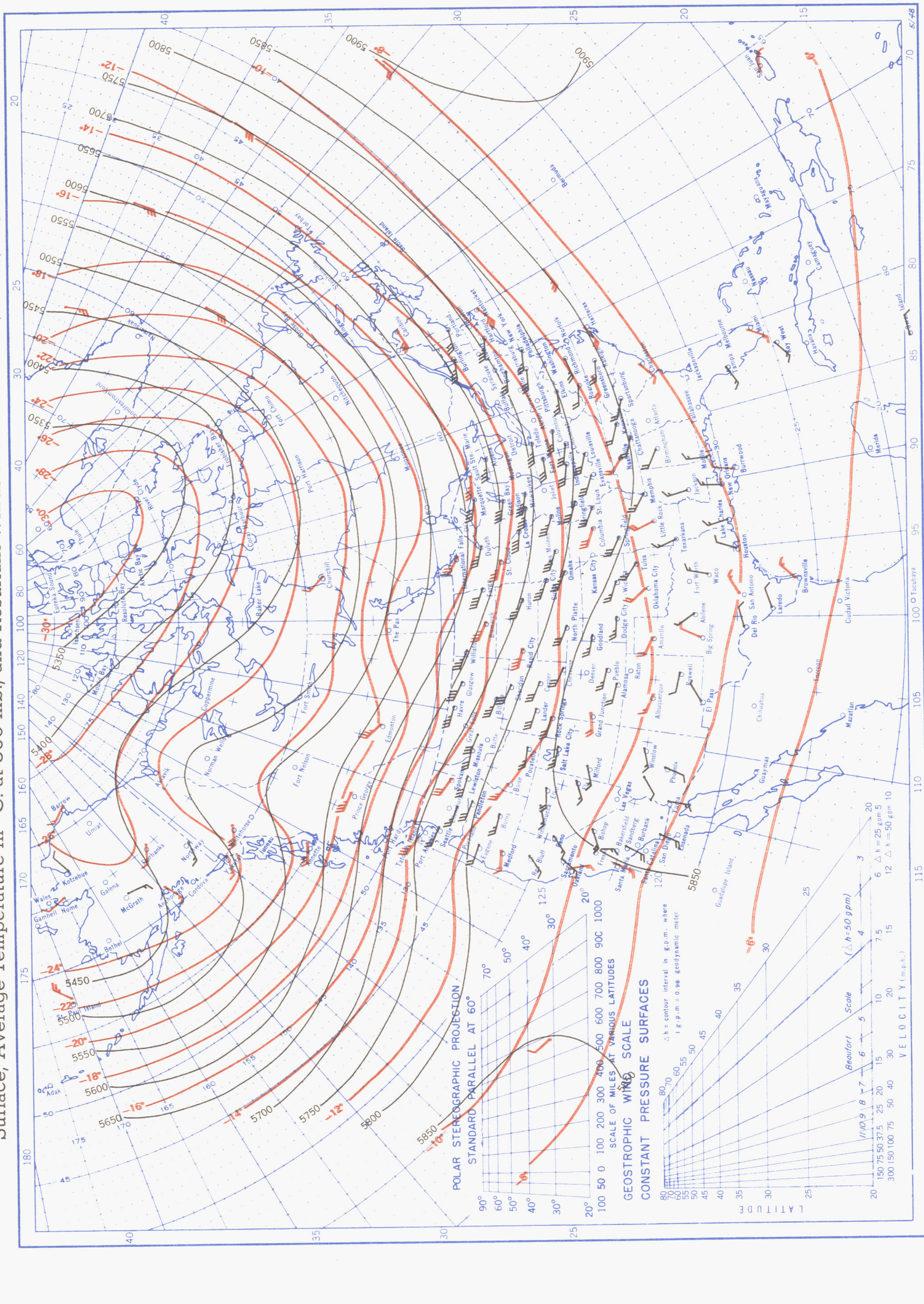

Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T.

Chart XIII. Average Dynamic Height in Geopotential Meters (1 g.p.m.. = 0.98 dynamic meters) of the 700-mb. Pressure Surface, Average Temperature in °C. at 700 mb., and Resultant Winds at 3000 Meters (m.s.l.), September 1953.



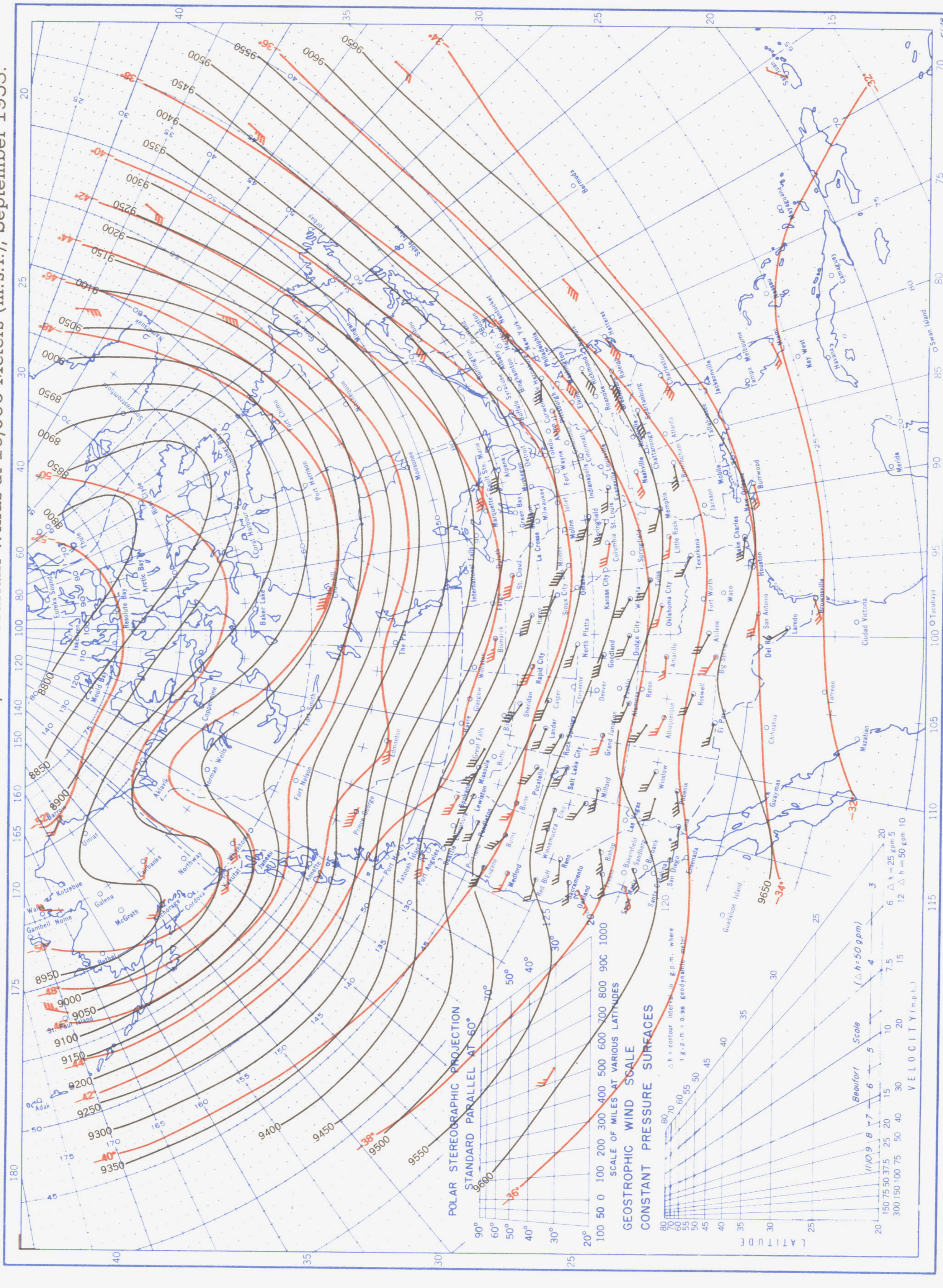

Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins taken at 0300 G. M. T.

Chart XIV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 500-mb. Pressure Surface, Average Temperature in °C. at 500 mb., and Resultant Winds at 5000 Meters (m.s.l.), September 1953.




Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T.

Chart XV. Average Dynamic Height in Geopotential Meters (1 g.p.m. = 0.98 dynamic meters) of the 300-mb. Pressure Surface, Average Temperature in °C. at 300 mb., and Resultant Winds at 10,000 Meters (m.s.l.), September 1953.




Contour lines and isotherms based on radiosonde observations at 0300 G. M. T. Winds shown in black are based on pilot balloon observations at 2100 G. M. T.; those shown in red are based on rawins at 0300 G. M. T.